V.F.

Nov 1957

88/57 (V.F.) VOLOSOV

... PHOTO AND MOVIE OPTICS IN THE USSR ...

photostat of original article
inside back cover.

Price: $.75

12 November 1958

59-11,048

JPRS (NY) L-427

Volosov, D. S.

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CONTEMPORARY STATUS OF PHOTO AND MOVIE OPTICS IN THE USSR AND IMMEDIATE PROSPECTS FOR ITS DEVELOPMENT

Zhurnal Nauchnoy i Prikladnoy
Fotografii i Kinematografi,
/Journal of Scientific and Applied
Photography and Cinematography/
Vol. 111, No. 1, Moscow, 1958,
pp 55-56

D. S. Volosov

Russian photo and projection optics, from its very beginning and up to our time, has gone through a comparatively short but effective development.

The production of photo optical equipment in pre-revolutionary Russia practically did not exist; only some individual shops were making the simplest objectives from imported glass and according to designs of foreign origin.

The beginning of the actual development of the complex branch of optical techniques is almost wholly connected with the work of the "S. I. Vavilov" State Optical Institute, which became the scientific and technical center of the entire optico-mechanical industry. This institute was organized soon after the October Revolution of 1918 and has greatly influenced the development of scientific and applied optics in our country.

The complex technique of cooking the basic types of optical glass was already mastered in the mid-1920s. Parallel with this was begun the work of creating Russian photographic objectives, which required working out theories and methods for their design, mastering methods of testing them, and organizing a simple and effective technology for their production and assembly. Although the development of the production of objectives in our country began considerably later than in some European countries, it has reached at the present time a high and up-to-date level in regard to the scale of production and technical equipment.

During the last quarter of a century photographic and projection optics have been developing in the direction of improving optical parameters of these systems by increasing

their relative apertures and field of vision and by improving the correction of their aberrations, which determine the quality of images - the resolution of the objectives and the contrasts of the details of the objects they form. These characteristics of objectives have been greatly improved, mainly as a result of the creation of new types of anastigmatic multi-lens systems, by the application of refracting and reflecting lenses, sometimes of aspheric forms, and by the application of optical media with different optical constants.

The order of development of Russian photo optics for the last decade has been close to the basic direction of foreign developments.

The first projects which were carried out in this field in our country in the 1920s had as their goal the simplest optical lens systems, which were obtained by studying the literature on the subject, patents, and samples of foreign origin (1,2) /Numbers refer to bibliography/ These were the two-component achromatic "Aplanta" type system, "Petzval" objectives, the "Triplett" three-lens system and their modification, the "Tessar" four-lens systems, the "Heliar" /Geliar/ systems, etc. As is known, all these systems had their optical schemes designed by foreign opticians. Interest at that time was focused on a four-lens system offered by G. G. Slyusarev, in which the last component, in contrast to the "Triplett" system, consisted of two simple lenses. A similar system under the trademark "Takhar" had appeared abroad sometime later. Much of the initiative had been displayed by I. A. Turygin, who designed an "Ortagoz" objective.

During the second half of the 1930s, systematic work was devoted to an investigation of the "Triplett" systems (N. P. Usanov) and "Tessar" systems (E. I. Hagenthorn) /Gagentorn/ Side by side with these projects investigations were conducted to develop more complex systems with higher optical characteristics - wide-angular distorting systems (V. N. Churilovsky), ortoscopic objectives (M. M. Rusinov) and relative aperture, wide-angle anastigmats (D. S. Volosov).

Projects were conducted simultaneously to establish

methods of laboratory testing for photographic objectives and for the organization of their production in the G. O. I /State Optical Institute/ (A. I. Tudorovskiy and E. N. Tsarevskiy) (2). Later projects to perfect methods of testing objectives were offered by L. N. Moroz and E. G. Yakhontov, and in recent years by A. T. Ashcheulov and V. A. Matveev.

The Great Fatherland War has naturally changed the themes of investigation and has directed all work in this field into a totally different channel. At the end of the war, however, lens construction projects were again started, this time on a larger scale and on the basis of accumulated experience.

At this time the designing of a series of original optical systems had already been completed; on this basis, groups of objectives for different purposes with a broad range of optical characteristics have been created (3): "Uran" relative aperture, wide-angle anastigmats (D. S. Volosov); "Russar" wide-angle, ortoscopic objectives (M. M. Rusinov) (8); "Tair" teleobjectives of higher relative aperture (D.S. Volosov), and some other types of systems.

A series of high quality mirror-systems having various optical schemes have been worked out for small-size photography, motion picture filming, astrophotography and for other purposes: with meniscus aberration compensator (D. D. Maksutov); with afocal compensator of parallel ray pencils (D. S. Volosov, D. Yu. Halpern /Galpern/, Sh. Ya. Pechatnikova); with a focal compensator in converging pencils(V. N. Churilovsky) and schemes of other authors (G. G. Slyusarev and E. I. Hagenthorn).

A series of photographic and projection objectives have been worked out for television and fluorography and for instruments designed to operate in the infrared range of the spectrum (D. S. Volosov, M. M. Rusinov, and others).

During the last few years, methods of planning and designing a group of wide-angle, anamorphous "Bifocator" systems have been worked out (D. S. Volosov and his collaborators Sh. Ya. Pechatnikova and P. G. Fakhretdinova). The

same laboratory worked out a theory of thermo-optical aberrations and made calculations for various systems having steady images under conditions of changeable temperatures.

The collaborators of the Leningrad Central Designing Bureau of the Ministry of Culture, USSR, (E. B. Kontorovich and A. I. Gan) and the Leningrad Institute of Motion Picture Engineers (the chair of D. S. Volosov), have perfected and broadened a specific number of normal motion picture film and projection objectives having different optical characteristics, during the last few years. The Leningrad Institute of Precision Mechanics and Optics (the chair of M. M. Rusinov) has also participated in the development of individual systems.

Books and monographs on the theory and methods of optical system designing - A. I. Tudorovsky (1), G. G. Slyusarev (4), D. S. Volosov (3) - have been published as well as a series of articles pertaining to the theories and methods of designing complex photo and projection systems.

The present scientific and technical level of USSR objective production, technical equipment, and technological progress of this branch of optical production allow photographic and projection systems of any complexity to be created and, if necessary, to be produced in any required quantity.

Unfortunately, in mass production, a serial sample of an objective still does not always preserve the desired qualities of a standard pattern. Extensive and extremely important work is still to be done in this direction; if it is not done, our future research work in creating more perfect systems might become futile to a large degree, as these systems have more and more complex optical schemes and therefore require more elaborate work.

In analysing the past development of domestic and foreign photo and motion picture optics and taking note of the most effective direction of projects in this field for the last few years, it seems to us that future substantial progress is possible on the basis of research and development in the following directions:

1) A theoretical investigation and designing of photogra-
mic and motion picture film anastigmats having highly ef-
ective apertures with the adaptation of some new optical
edia, especially heavy crowns of the lanthanum type and
rystals (lithium fluoride, fluorspar, etc.).

2) An investigation of optical schemes and designing of
ide-angle photographic and particularly motion picture
ilming systems having highly effective aperatures with a
arge rear focal segment for monoobjective mirror-like
hoto apparatuses and for motion picture cameras with
irror-like obturators.

3) Designing of new optical schemes and development of
nastigmatic systems with variable optical characteristics
hich are alterable either continously or at discretion:

a) Objectives with a smoothly variable focal distance
or motion picture filming and television;

b) Objectives with changeable front components for a
hoto apparatus with central shutters.

4) Development of a theory and methods of designing for
namorphous systems and for the further improvement of ob-
ective anamorphites in the following directions:

a) Preservation of optical properties of an anamor-
hite within the limits of the whole field of vision and for
ll distances of pictured objects;

b) Increase in depth of the sharpness of the image
pace;

c) Widening of the angle of the field of vision of
namorphous systems.

5) Designing of especially wide-angled anastigmats having
ncreased relative aperatures for first rate photo appara-
uses as well as for motion picture filming on a wide frame.

The projects mentioned above are being carried out by us
ut not with equally successful results. Let us discuss some

optical systems which have been developed during the last few years and their characteristics, keeping in mind the field of their direct application and possible utilization. At the same time we will consider some new systems which have original optical schemes, and not only objectives which are serially produced but experimental designs as well, because the latter characterise the nearest perspectives in each field.

Photographic Objectives for Widely Applied Photo Apparatuses

We have in mind first of all objectives of photo apparatuses with 35 millimeter film for the 24 x 36 millimeter size. These apparatuses are equipped with a complete set of objectives whose optical characteristics are similar to those produced in many countries of the world. A set of objectives has been worked out with a focal distance from 20 to 1,000 millimeters for a given image size.

In this set, the following new objectives having original optical systems can be mentioned:

a) The "Tair-11" teleobjective, having a highly effective luminosity with a focal distance of 135 millimeters. A relative aperture of 1:2.8 has been obtained as a result of the application of a new four-lens system. The objective of the "Jupiter-11" series also consists of four lenses but it has a different optical system (the "Zonnar" type by K. Zeiss) whose relative aperture is not higher than 1:4. Figure 1 shows the optical system of the "Tair-11" objective and the curve of its photographic resolution in comparison to the "Zonnar" type:

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Fig.1 - "Tair-11" teleobjective.

Figure 1a. shows the increased images of the experimental patterns in the center of the field and for different zones of the field. An examination of this material allows us to draw a favorable conclusion about the high qualities of the

"Tair" objective, taking into consideration its simple construction.

A synthesis of the system and its method of design is given in D. S. Volosov's book (3). The same book also presents a synthesis of a series of other systems under consideration here and is made on the basis of the third order aberration theory.

b) The "Tair-3" teleobjective with a long focal distance of 300 millimeters and a relative aperature of 1:4.5. Having a simple three-lens optical scheme (Fig. 2), this objective projects a good quality image.

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Fig. 2 - "Tair-3" Teleobjective.

The "Tair" optical scheme (5) has found good application as an initial system for the development of objectives for different purposes in photography, motion picture filming, and television, for making objectives of wide-angle telescopic systems, for interference systems, etc.

c) Mirror-like meniscus teleobjective (MTO) with focal distances of 500 and 1,000 millimeters. The meniscus objective is adapted to compensate for a spherical aberration caused by mirror components of the system. The mirror part of the system consists of two mirrors. Similar systems of a comparatively smaller length can be obtained by the application of special conical or cylindrical diaphragms (7), which eliminate the possibility of spoiling the film by beams of light that failed to get double reflection from the mirror. Such systems are small in size and are effective for use in portable cameras used by reporters and amateurs as well as in motion picture filming and television equipment.

Figure 3 shows their optical scheme and the resolution curve of the MTO objective, f'= 500 millimeters. The total length of this objective, i.e., the distance from the first refracting surface to the focal surface is one-third of the

focal distance of the objective. The objective with f'= 1,000 millimeters has a length equal to only one-fourth the focal distance.

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Fig. 3 - MTO Mirror-type Teleobjective.

d) The "Mercury-1" relative aperture objective for the high quality "Kiev" and "Leningrad" photo apparatuses, etc. The objective of the "Jupiter-8" series, f'= 50 millimeters, relative aperture, 1:2, which is a basic objective for the cameras mentioned above, has a satisfactory relative aperture only in panchromatic layers, providing that the latter's effective resolution is not high. The application of materials with a high resolution increases the relative aperture at the center of the field but does not bring about any substantial increase of the photographic luminosity of the objective throughout the field. This is due to its comparatively large residual aberrations, in which the effective dimensions of the diffusion shapes of rays, forming a nucleus of image points, are large.

As a result of many investigations and calculations, the author and his collaborator, R. G. Fakhretdinova, have succeeded in computing an objective with smaller residual aberrations than the "Jupiter-8", with the same optical characteristics. Projects in this direction, as is known, are being carried out in many countries. The Leitz Firm (FRG) in particular has made an imporved objective called "Summikron". The curves of its resolution are shown in Fig. 4b.

As one can see, the relative aperture of the "Summikron" objective on a panchromatic film is only slightly higher than that of the "Jupiter-8" objective. The substantial difference, however, in "Summikron" is the use of a highly effective material called "Mikrokopi" /Microcopy/. An improved quality of images in the "Summikron" System had been obtained by the application of a more complex seven-lens scheme for its objective, where in the composition of its four positive lenses, lanthanum crowns, the expensive

components are the oxides of rare earths.

Our calculations have shown that in a complex optical scheme of no more than seven lenses, an objective can be made by the application of standard optical glasses, whose aberration within the limits of the whole field is identical to the aberrations of the "Summikron" system.

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Fig. 4a - "Mercury-1" Relative Aperture Objective.
4b - Photographic Resolution of Objectives: 1- "Summikron" 2- "Jupiter-8"

The standard type of glasses are adapted to the developed "Mercury-1" objective. The optical scheme of this objective is shown in Figure 4a. More detailed information pertaining to this objective will be published later.

c) Wide-angle "MP-2" objective with a 19.5 millimeter focal distance, a 95 degree angle of the field of vision, and a relative aperture of 1:5.6. The optical scheme of this objective is that of the six-lens "Russar" type. (8)

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Fig. 5 - Wide-angle "MP-2" objective of the "Russar" type

This objective has less decrease of image illumination throughout the field, i.e., from the center of the field to its periphery, the illumination of images decreases proportionally to the cosine of the third degree of the beam of vision and not of the fourth degree as for the previous wide-angle objectives.

The objectives of mirror photo apparatuses ought to have an increased rear focal segment length, as a flap mirror is located at the rear of the objective in these apparatuses. This construction peculiarity causes much trouble in the development of short-focal, wide-angle objectives which ought to have a disproportionally increased rear segment in compar-

ison with their focal distance.

The following new objectives were designed for these apparatuses:

1) Wide-angle "Mir-4" objectives with a focal distance of 28 millimeters and a relative aperture of 1:3.5 and a rear focal segment of 38 millimeters which is about 40 percent in excess of its focal distance. The angle of its field of vision reaches 76 degrees. The objective has a new optical scheme (Fig.6) and consists of eight lenses (9).

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Fig. 6 - Wide-angle "Mir-4" Objective
Fig. 7 - "Helios-65" /Gelios/ Relative Aperture Objective

The objective with the shortest focal distance of all those previously developed for these cameras, the "Mir-1", has a focal distance of 37 millimeters, which is equal to its rear focal segment; this objective has a six-lens optical scheme.

2) The "Helios-65" relative aperture objective has a focal distance of 50 millimeters and a relative aperture of 1:21; its rear segment is 38 millimeters, which until now had been reached only at a focal distance of 58 millimeters in this type of system and consequently had a smaller angle of the field of vision.

The "Helios-44" objective in particular, adapted for the "Zenith" camera, has the optical characteristics similar to a German "Biotar" objective, namely: f'= 58 millimeters; relative aperture, 1:2; 2B= 40 degrees.

A prospective problem is to create a set of objectives of different focal distances for cameras with central shutters. This can be achieved by the application of changeable components installed in front of the aperture diaphragm. Some known solutions to this problem as well as the existing construction of systems are not quite satisfactory; in particular the large size of these systems considerably

reduces their operational qualities.

New, higher quality objective-anastigmats have been developed for images of 6x6 and 6x9 centimeters as follows:

1) Wide-angle "MP-3" objective, having an original six-lens "Russar" optical scheme similar to the scheme shown in Figure 5. Its focal distance is 35 millimeters, its relative aperture is 1:6.8 and the angle of the field of vision is 120 degrees. The linear dimensions of images correspond to the size of pictures up to 6 x 9 centimeters.

2) Wide-angle, relative aperture "Uran-13" anastigmat, having an original (10) seven-lens scheme (Fig.8). Its focal distance is 70 millimeters, its relative aperture, 1:2.5, and its angle of the field of vision, 61 degrees, which corresponds to the size of a 6 x 6 centimeter picture.

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Fig. 8 - The "Uran-13" wide-angle, relative aperture objective.

An anastigmat has been developed for 6 x 9 centimeter pictures, the "Uran-27", with a focal distance of 100 millimeters and an aperture of 1:2.5. The "Uran" type systems have a general purpose optical scheme which can be taken as a basis for the development of objectives with a broad range of optical characteristics, depending on their field of application, i.e., with focal distances from 13 to 750 millimeters, relative apertures from 1:2 to 1:3.5, and with field vision angles from 63 to 35 degrees.

3) "Tair-7" teleobjectives, with a focal distance of 300 millimeters and a relative aperture of 1:4.5, have a simple three-lens scheme similar to that shown in Figure2; they give images of good quality in picture sizes up to 6 x 9 centimeters.

The rest of the objectives developed for pictures of these sizes have ordinary optical schemes, therefore, we will not discuss them.

Optics for Usual (Normal) Cinematography

-A. Motion picture filming objectives have been perfected as follows during the last few years:

a) By increasing their resolution and the quality of pictures, with 35-millimeter color film in mind. The objectives of this group have been mainly improved by increasing the chromatic correction quality of aberrations in widely-inclined ray pencils within the limit of the whole field of vision. The existing set of objectives for a normal sequence of 35 millimeter film has the following optical characteristics: their focal distances change within the limits of 16 to 500 millimeters; their relative apertures are from 1:2.8 to 1:3 respectively - the short focal distance objective has an aperture of 1:3 while the long focal distance systems have them up to 1:5.6. The objectives of the middle range focal distances have apertures of 1:2.

The new optical systems have been adapted to some of these objectives. Objectives with focal distances of 25 and 35 millimeters and with a higher relative aperture of 1:2 have been developed according to the "Uran" optical scheme (Fig. 9), The teleobjective PO-67 has a "Tair" scheme similar to the one shown in Figure 1. Its focal distance is 150 millimeters and its relative aperture is 1:2.8; the resolution curve of this highly qualified objective is shown in Figure 10a.

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Fig. 9 - "Uran-20" Objective

Fig. 10 - Photographic Resolution of Motion Picture Objectives: a-PO-67; b-PO-71

The following teleobjectives are made according to the same "Tair" optical scheme (5): the PO-68, with a focal distance of 200 millimeters and the PO-69, with a focal distance of 300 millimeters; their relative apertures are 1:2.8 and 1:3.5 respectively. These objectives give images of high quality.

The ZM-30 and ZM-50 long focal distance systems of 300

and 500 millimeters are made according to the meniscus scheme (6) mirror-lens teleobjectives (Fig. 3). Their respective relative apertures are 1:3 and 1:5.6. These objectives are very portable and therefore convenient for operational purposes.

b) By developing relative aperture, wide-angle objectives with large rear focal segments. Investigations in this direction are being conducted in many countries. This problem is one of the most difficult in quantitative optics.

The basic data on designing and the results of calculations for these USSR objectives are published by their authors (9). Serially produced, the eight-lens PO-71 anastigmat has a focal distance of 18 millimeters, a relative aperture of 1:2.8, and a field of vision of 76 degrees; its rear focal segment is 22 millimeters. The resolution within the limits of the entire vision field is substantially higher than that of the systems of similar optical characteristics known to us. It is particularly higher than that of the "Petrofokus" objective made by the Anjene Firm in Paris, which has a focal distance and rear segment of only 19 millimeters. The optical scheme of the PO-71 objective is similar to the scheme represented in Figure 6. Its resolution curve is shown in Figure 10b.

The same authors have worked out the PO-72 objective, which has a new nine-lens optical scheme (Fig.11). At a focal distance of 16 millimeters, its rear focal segment reaches 25 millimeters. Its field of vision is 82 degrees and its relative aperture is 1:3. The quality of this objective is close to that of the previous system.

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Fig. 11 - Relative Aperture, Wide-angle, Motion Picture Film Objective PO-72

B. The anastigmats with more highly effective relative apertures for normal and narrow-film motion picture projection are as follows:

a) The new six-lens PO-500, 501, 502, and 503 objectives with corresponding focal distances of 90, 100, 110, and 120 millimeters and a relative aperture of 1:2 have been produced for normal 35 millimeter frame projection. They are made for stationary installations in large movie houses as well as for wide frame projection, 18.7 x 23.8 millimeters, on a wide screen.

b) For 16 millimeter frame projection, relative aperture PO-109, 110 and 111 anastigmats have been developed, all having the original (11) optical scheme (Fig. 12).

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Fig. 12 – Special Relative Aperture Projection Anastigmat PO-110.

The optical characteristics of these objectives are: focal distances - 35, 50, and 60 millimeters; corresponding relative apertures - 1:1.2; 1:1.2; 1:1.4. The objectives are set in a "Ukraina" narrow-frame projector.

<u>Optics for Wide Screen Cinematography</u>

The development of wide screen cinematography is planned in two directions:

A. By anamorphosis of the image on 35 millimeter film (18.7 x 23.8 millimeter frame) as well as its projection upon a screen with the ratio of the sides 2.55:1.

B. By the application of wide 70 millimeter motion picture film with a frame sides ratio of 2.2:1. Filming is done with wide-angle spherical optics on a 50 x 23 millimeter frame size. The projection window dimensions are 40.6 x 22 millimeters. Projects in this dimension are still in the experimental stage.

Let us discuss somewhat in detail the optical development stage

for these purposes.

A. Anamorphous optical systems for motion picture filming and projection.

The accepted frame size 18. 7 x 23.8 millimeters, with 2.55:1 as the ratio of the screen width to its height, requires double anamorphosis of an image during filming as well as during projecting. For this purpose anamorphous settings consisting of cylindrical lenses are applied, with the parallel generatrices of the cylinder sets in front of the ordinary filming or projection objectives.

Working out anamorphous projection systems does not present any unusual difficulties in as much as their angle of the field of vision is not large (not more than 20 degrees) and therefore those specific distortions of images which are inherent in wide-angle filming anamorphites have not yet appeared. The technology of making and assembling anamorphites for projection is also considerably simpler than for films, and is carried out without any particular difficulties after experience is obtained in mastering the production of the more complex filming optics. This is the reason why at the present time only the cylindrical projection anamorphites are being produced in the USSR, although the manufacturing of prismatic anamorphites seems to be somewhat simpler. Prismatic projection anamorphites do not permit the angles of the field of vision to be more than 13 to 15 degrees, while the dimensions of some wide-screen motion picture theaters require the application of wider angle optics.

Taking these circumstances into consideration, we are producing the universal projection anamorphitic setting which consists of four cylindrical lenses, and which forms a two-component system. Its angle of the field of vision and the dimensions of the aperture from the side of the spherical projection objective are such that they allow projection by different replaceable objectives with focal distances from 80 to 130 millimeters and with relative apertures up to 1:2.

Considerably greater difficulties arise in designing wide-angle, motion picture filming anamorphites.

During the last two years, wide-angle "Bifokator" anastigmatic systems have been designed by the G. O. L, the TSKB /the Central Designing Bureau/ of the Ministry of Culture, and the "Lenki /ts/ap" Factory, as a result of theoretical investigations and development in calculation methods (12). These systems are serially produced under the trademark NAS (meaning anamorphitic removable setting). The first variants of these systems are being worked out for motion picture filming with objectives having a focal distance of 50 millimeters and a relative aperture of 1:2 (NAS-1) or with a focal distance of 40 millimeters and relative aperture of 1:2.5 (NAS-3). The NAS-1 system can also be used with objectives having a focal distance of 80 and 100 millimeters and respective relative apertures of 1:2 and 1:2.5. The NAS-3 system can also be used with objectives having focal distances of 50, 80, and 100 millimeters, and respective relative apertures of 1:2, 1:2, and 1:2.5. Distance focusing is achieved by adjusting a spherical objective and one of the components of the anamorphitic setting, i.e., for the first system by adjusting the first component, and for the second system by adjusting the inside lens. Figure 13 shows optical schemes of these anamorphites in meridional cross section.

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Fig. 13 - Optical Schemes of "Bifokator" Anamorphitic Systems NAS in Meridional Section

The systems have a good correction for monochromatic as well as for chromatic aberrations within the whole field of vision; their photographic resolution on panchromatic film is close to that of spherical filming objectives located behind the anamorphitic system, i.e., about 35mm at the center of the field and 30 - 25 mm^{-1} throughout the field.

A constancy in anamorphosis has been obtained throughout the field with an accuracy of about five percent for anamorphites developed on the basis of a theoretically established dependence of anamorphosis alteration in the field on the character of changes in distortion (its size and first derivative). This accuracy is quite permissible, as has been

shown by experimental and operational tests.

A small size NAS-4 anamorphitic system whose optical characteristics are identical to those of the NAS-1 system has been developed for portable newsreel filming cameras (12). The length for setting does not exceed 100 millimeters. The diameter of the first and largest lens is 64 x 60 millimeters. Distance focusing is achieved by adjusting the second component of the setting. Constructively this method is more effective.

At the present time, the same authors in the G. O. L. have finished calculations for a new wide-angle "Bifokator-5" anamorphite (NAS-5) which has an invariable anamorphosis for all distances of filming from 1.2 meters to infinity. This is achieved through the fact that the second component of the system (Fig. 13b) has in its meridional section a variable focal distance which changes synchronously with the movement of those components of the system which are responsible for distance focusing. The optical qualities of the system are preserved and are identical to those mentioned above in the "Bifokator" (NAS) variations.

The primary variants of anamorphites, like all the existing systems, have a specific characteristic - a distance in depth of the image space in different sections of an anamorphite, which substantially reduced their operational qualities. This characteristic adversely affects the quality of the images of differently oriented objects located outside of the guiding surface (nearer or farther from the surface on which the system is focused). In the new "Bifokator" system, the aperture diaphragm is not round but elliptical and is located inside of a spherical objective. This arrangement assured the identical depth of the sharpness of objects for all film objective orientations located outside of the guiding surface. (Practice in using these systems completely justified this arrangement.)

There remains a question which is still theoretically unanswered, namely, the question of aberration in image distortions of vertical and horizontal lines in wide-angle anamorphitic systems, and the means for its correction. Until this question has been completely answered, the devel-

opment of still wider angled anamorphites can not be carried out. There also remains the question of investigating the practicality of applying toricheski /thorium-covered/ surfaces, which apparently can simplify the optical schemes of these systems.

B. Wide-angle optical systems for wide frame photography and projection on 70-millimeter film.

In this case, the application of a large size 50 x 23 millimeter frame will satisfy the requirements of the wide motion picture screen system; 48.6 x 22 millimeters will be the dimensions for the projection window, which corresponds to a 2.2:1 ratio of the sides.

Here the filming objectives have an unusually large vision field angle; the basic objective has a field angle of about 70 degrees which corresponds to a focal distance of 40 millimeters; its relative apertures for good quality aberration correction is 1:3.5. The optical scheme of the objective is similar to the scheme shown in Figure 6. The long-focus objective has a seven-lens optical system; its angle of the field of vision is 52 degrees, its focal distance is 56 millimeters, and its relative aperture is 1:3. The short-focus objective, which is still in the development stage, should have a 28 degree field vision angle, a focal distance of 13.5 millimeters, and a relative aperture of about 1:3.5.

No less difficulties are ahead for the development of a projection objective which can project images on a strongly concave cylindrical screen. This compensates for the perspective distortions of images which are caused by the distorted screen. The optical characteristics of such an objective are: focal distance- 60 millimeters; relative aperture - 1:2; angle of the field of vision - about 50 degrees. With the unusually large field for projection objectives, it should not "vignette" the wide, inclined rays, as it has an aberration correction quality which is high. This problem is very difficult and ways to satisfactorily solve it are not yet clear.

Special Photographic and Projection Objectives

Let us discuss the following three groups of special purpose objectives:

A. Relative aperture objectives for photographing images from electronic tube and fluorography screens.

Samples of mirror-lens objectives with a relative aperture of 1:1 and a focal distance of 110 millimeters have been developed for these purposes; the size of the image which they project corresponds to that of normal 35-millimeter film.

All refracted and reflected surfaces of the system are of a spherical form. Figure 14 shows the optical scheme, developed by E. I. Hagenthorn (13). Photographs with dimensions of 1:4 to 1:7 can be made with this objective; it projects high quality images and resolves visually at the center of the field at about 400 mm^{-1} and throughout at 300-200 mm^{-1}.

An objective of the same type has been developed for photographing with 16 millimeter film; this objective has a focal distance of 55 millimeters and a relative aperture of 1:0.85, with a resolution on panchromatic film of 55mm^{-1} in the center of the field and 40 mm^{-1} throughout the field.

A ten-lens objective has been designed for wide frame fluorography; it has a relative aperture of 1:0.75 and a vision field angle of 25 degrees. The image surface with linear dimensions of 85 millimeters is flat.

A mirror-lens objective has also been designed for the same purposes and has a conical compensating plate which corrects aberrations of the wide, inclined rays throughout the field, whose angular dimensions reach 25 degrees. The system has a relative aperture of 1:0.75 with a spherical image surface. The dimensions of the photo screen, with filming scales of 1.5 to 1.6, reach 350 x 350 millimeters. In comparison to the Schmidt mirror system, this objective has a substantially better correction for wide, inclined rays within the limits of the entire field.

All these systems are designed in the G.O.I. (the laboratory of D. S. Volosov). Projects in this direction are

being conducted in many countries, particularly in Holland by the "Odelka" Firm. The optical system of these objectives is shown in Figure 15.

B. Objectives with especially high relative apertures for photography and television under conditions of reduced objective brightness.

An especially high relative aperture mirror-lens objective has been developed for photographing remote objects under lowered illumination conditions or for projecting images of these objects on the photo-cathode of television tubes in transmitting cameras. Its relative aperture is 1:0.6 and its focal distance, 145 millimeters; the linear image field is 24 x 24 millimeters. The visual resolution at the center of the field is about 400 mm^{-1} and 200 to 100 mm^{-1} throughout the field. The optical scheme of the objective, analagous to the scheme shown in Figure 14, but without the setting focal lens, is shown in Figure 16. All optical surfaces of this system have a spherical form.

[p.63 of text]
Fig. 14 Optical Scheme of a Mirror-lens Objective
Fig. 15 The Scheme of a Mirror-lens Objective with Conical Compensating Plate
Fig. 16 The Scheme of a Mirror-lens Objective with Especially High Relative Aperture

An objective has been developed on the basis of the same optical system with a focal distance of 55 millimeters for 7.5 x 10 millimeter picture sides, whose photographic resolution or panchromatic is over 50 mm^{-1} at the center of the field and about 40 mm^{-1} throughout the field.

C. Objectives with Variable Focal Distances

Great theoretical investigations and calculations have been carried out in connection with the problem of creating objectives with continously variable focal distances (3) for motion picture filming and television.

The simplest forms of its optical schemes (14) is the "Idar-2" system which consists of three plain glued components (Fig 17).

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Fig. 17 - "Idar" Objective with Variable Focal Distance.

The objective has an uninterruptedly changeable focal distance within the limits of 32 to 95 millimeters; the relative aperture is 1:3.5 for focal distance intervals of 32 to 62 millimeters and 1:5.3 for the whole variation interval of the focal distance. The first and third components of the system are rigidly tied up with each other and move along a screw with invariable spacing in relation to the stationary image plane; the second component of the objective also moves along a guide in relation to this plane; the equation of the guide is expressed by a polynomial of the second degree. The objective has a good quality image for all focal distances. A contrast of pattern streak images with a frequency of 25 mm^{-1}, according to measurements by A. T. Ascheulov's group on an especially developed photoelectric microphotometer, reaches 90 to 93 percent for all focal distances. The resolution of this objective on panchromatic film is 50 mm^{-1} in the center of the field for small focal distance sections and 40 mm^{-1} for medium and large focal distance sections; throughout the field it is 30 - 25 mm^{-1} for all focal distances of the objective.

During the last few years, work has been carried out in the author's laboratory on a system with a wide range of focal distance variations. M. S. Stefanskiy has designed a "Neon-1" objective which has a smooth variation of focal distances from 35 to 193 millimeters, i.e., 5.5 times. The relative aperture of this system is 1:3 for all focal distances. The picture size corresponds to that of a normal frame 35 millimeter film. The optical scheme of this objective is shown in Figure 18.

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Fig. 18 - " Neon" Objective with Variable Focal Distance.

The objective is well corrected in relation to all aberrations - monochromatic as well as chromatic. A focal distance variation is achieved by moving components II, III, and IV of the telescopic variable magnification adjustment, which is installed in front of the objective. In comparison with the known systems of the "Tranfokator" type (the "Astro" Firm), the "Neon" system has a substantially better correction for aberrations of wide, inclined pencils within the limits of the whole field and for all focal distances; also it has a good chromatism correction.

In perspective remains the problem of creating small dimension and long focal systems with a variable image scale. A practical trend regarding this seems to be in the direction of developing mirror-lens systems with a continuously changeable focal distance.

Conclusion

We have briefly stated the results of investigation and development in the basic direction mentioned at the beginning of this article. The analysis of the results shows that the future improvement of optical characteristics of objectives and an increase in image quality seems to be real and workable provided that:

a) optical schemes of systems become more complex, as this will permit improving the correction of higher order aberrations;

b) there will be a broader application of reflecting surfaces; this will allow especially high resolutions as well as small dimension, long-focal systems to be developed;

c) there is a practical utilization of new optical media - special type of glasses and crystals of lithium fluoride and fluorspar;

d) refracting and reflecting surfaces of aspheric forms are applied, mainly in systems with large relative apertures and small fields of vision as well as in wide-angle systems having small apertures.

e) photographic films having a higher relative aperture are applied. A low resolution of widely applied photographic materials, in particular, of multi-colored films, even in a further increase of the objective's own resolution, will not permit any considerable increase of the resolution characteristics of the "objective-photo film" system, if the resolution of the latter is not substantially increased.

Bibliography

1. Tudorovskiy, A. I., Teoriya Opticheskikh Priborov /The Theory of Optical Instruments/, published by Academy of Sciences, USSR, Vol. 1, 1948 and Vol. 2, 1952.
2. Tudorovskiy, A. I., An article in a collection entitled XV Let Gosudarstvennogo Opticheskogo Instituta /"Fifteen of the State Optical Institute"/ GTTL, M. -- L. 1934.
3. Volosov, D. S., Metody Rascheta Slozhnykh Fotograficheskikh Sistem /Methods of Calculating Complex Photographic Systems/, GITTL, 1948.
4. Slyusarev, G. G., Metody Rascheta Opticheskikh Sistem /Methods of Calculating Optical Systems/, ONTI, 1937.
5. Volosov, D. S., Sakhnovich A. E., Fakhredtinova P. G., Author's Certificate # 78122, priority of 3 November 1944.
6. Maksutov, D. D., Works of G.O.I. (State Optical Institute), 1944 XVI, 124.
7. Volosov, D. S., Author's Certificate # 64794, priority of 16 August, 1943.
8. Rusinov, M. M., Author's Certificate # 66197, priority of 8 January 1944.
9. Volosov, D. S., Kontorovich, E. B., Technical Information Bulletin of TSKB, Ministry of Culture, # 2, 1956.
10. Volosov, D. S., Author's Certificate No. 0275-333251, priority of 21 June, 1944.
11. Volosov D. S., Persina M. B., Shakhnovich A. E., Author's Certificate No. 102217, priority of 30 October, 1950.
12. Volosov D. S., Pechatnikova Sh. Ya., Optiko-mekhanicheskaya Promyshlennost' /Optico-Mechanical Industry/, No 2, 1957.
13. Hagenthorn, E. I., priority of 15 June 1950 on application No. 427011.
14. Volosov D.S., Author's Certificate No. 59390, priority of 29 December 1939.

END

«Неон» обладает существенно лучшим исправлением аберраций широких наклонных пучков в пределах всего поля и для всех фокусных расстояний и хорошей коррекцией хроматизма.

Перспективной остается задача создания малогабаритных длиннофокусных систем с переменным масштабом изображения. Рациональным направлением здесь, по-видимому, является разработка зеркально-линзовых систем с непрерывно изменяющимся фокусным расстоянием.

Заключение

Мы кратко изложили результаты исследований и разработок в основных направлениях, перечисленных в начале статьи. Анализ этих результатов показывает, что дальнейшее совершенствование оптических характеристик объективов и повышение качества изображения представляется реальным при условии:

а) дальнейшего усложнения оптических схем систем, что позволит улучшить коррекцию аберраций высших порядков;

б) более широкого применения отражающих поверхностей, что позволяет создавать особо светосильные, а также малогабаритные длиннофокусные системы;

в) рационального использования новых оптических сред — особых типов стекол и кристаллов фтористого лития, флюорита;

г) применения отражающих и преломляющих поверхностей асферической формы, главным образом в системах большого относительного отверстия и малого поля зрения, а также в широкоугольных системах, имеющих небольшие отверстия;

д) применения более высокоразрешающих фотографических слоев; невысокая разрешающая сила широко применяемых фотографических материалов, в частности многослойных цветных пленок, даже при дальнейшем повышении собственной разрешающей силы объектива не приведет к сколько-нибудь значительному возрастанию разрешающей способности системы «объектив — фотослой», если разрешающая сила последнего не будет существенно увеличена.

ЛИТЕРАТУРА

1. Тудоровский А. И., Теория оптических приборов, Изд. АН СССР, т. 1, 1948 и т. 2, 1952.
2. Тудоровский А. И., статья в сб. «XV лет Государственного оптического института», ГТТИ, М.— Л., 1934.
3. Волосов Д. С., Методы расчета сложных фотографических систем, ГИТТЛ, 1948.
4. Слюсарев Г. Г., Методы расчета оптических систем, ОНТИ, 1937.
5. Волосов Д. С., Шахнович А. Е., Фахретдинова Р. Г., Авт. свид. № 78122, приоритет от 3 ноября 1944 г.
6. Максутов Д. Д., Тр. ГОИ, 1944, XVI, 124.
7. Волосов Д. С., Авт. свид. № 64794, приоритет от 16 авг. 1943 г.
8. Русинов М. М., Авт. свид. № 66197, приоритет от 8 янв. 1944 г.
9. Волосов Д. С., Конторович Э. Б., Информ.-техн. бюлл. ЦКБ Мин. культуры СССР, № 2, 1956.
10. Волосов Д. С., Авт. свид. № 0275—333251, приоритет от 21 июня 1944 г.
11. Волосов Д. С., Персина М. Б., Шахнович А. Е., Авт. свидет. № 102217, приоритет от 30 октября 1950 г.
12. Волосов Д. С., Печатникова Ш. Я., Оптико-механическая промышленность, № 2, 1957.
13. Гагенторн Е. И., Приоритет от 15 июня 1950 г. по заявке № 427011.
14. Волосов Д. С., Авт. свидет. № 59390, приоритет от 29 окт. 1939 г.

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ФОТОГРАФИЧЕСКОЕ ОБРАЗОВАНИЕ В ВЫСШИХ УЧЕБНЫХ ЗАВЕДЕНИЯХ *

ВЫСШЕЕ ХИМИКО-ФОТОГРАФИЧЕСКОЕ ОБРАЗОВАНИЕ В ЛЕНИНГРАДСКОМ ИНСТИТУТЕ КИНОИНЖЕНЕРОВ

Основным специальным высшим учебным заведением, готовящим в СССР инженеров по фото-кинотехнике, является Ленинградский институт киноинженеров (ЛИКИ).

Следует немного остановиться на истории этого института. В сентябре 1918 г. постановлением Совета народных комиссаров РСФСР в Петрограде был организован Высший институт фотографии и фототехники. Этот институт был одним из восьми научных учреждений, в первую очередь организованных молодой советской властью в

* Настоящей статьей мы открываем серию сообщений о высшем фотографическом образовании в СССР и за рубежом (*Ред.*)